Radar Open System Architecture & New Development Efforts For The Lincoln Space Surveillance Complex (LSSC)

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4 April, 2001

This work is sponsored by the Air Force under A/F contract #19628-95-C-0002. Opinions recommendations and conclusions are those of the author and are not necessarily endorsed by the United States Air Force

Acknowledgments

- Stephen Rejto & Timothy Hiett – ROSA System
- John Harris – Waveform Generator
- Dr. Jonathon Twitchell & Jeffrey Hargreaves – PACT System

Definitions

- **Open Systems (DOD/SEI)**
  - **“ An open system is a collection of interacting software, hardware and human components, designed to satisfy stated needs, with the interface specification of components fully defined and available to the public, maintained according to group consensus and in which the implementation of components are conformant to the specification. ”**
- **COTS (summary from Federal Acquisition Regulations)**
  - **Customarily used for nongovernmental purpose and has been sold, leased or licensed to the general public**
  - **Exists a priori (in a catalogue or price list)**

Outline

- Objectives & Motivation
- Radar Open System Architecture (*ROSA*)
  - Radar Architectures Old & New
  - Benefits
- *ROSA* Applications
- New LSSC Development Efforts
- Status & Summary

Objectives & Motivation

- Establish an open systems approach as the foundation for radar systems development in order to:
  - Lower development time
  - Improve life-cycle costs
  - Increase systems performance
- Improve :
  - Portability
  - Interoperability
  - Compatibility
  - Reusability
  - Maintainability
  - Affordability - improve acquisition model
  - Scalability- quick insertion of new technology
- Develop plug-and-play radar components
  - Share components between DOD programs
  - Migrate to commercial world

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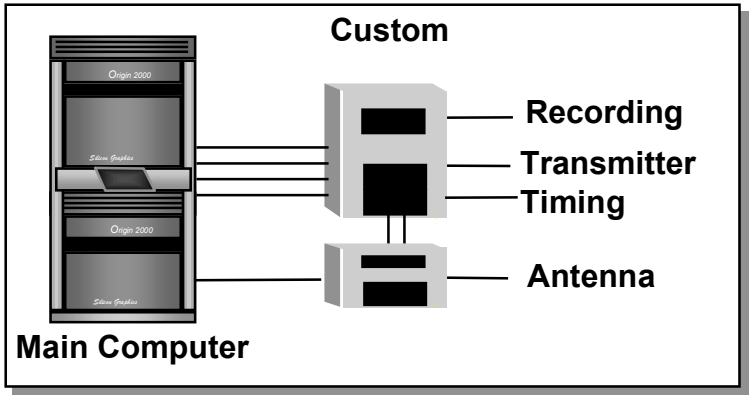
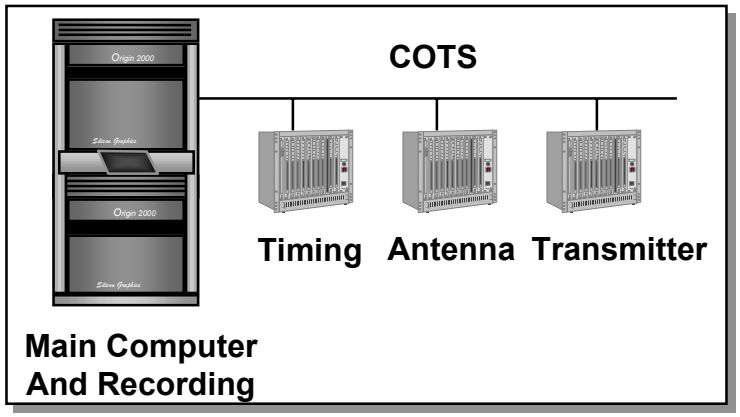
Radar Architectures Old & New

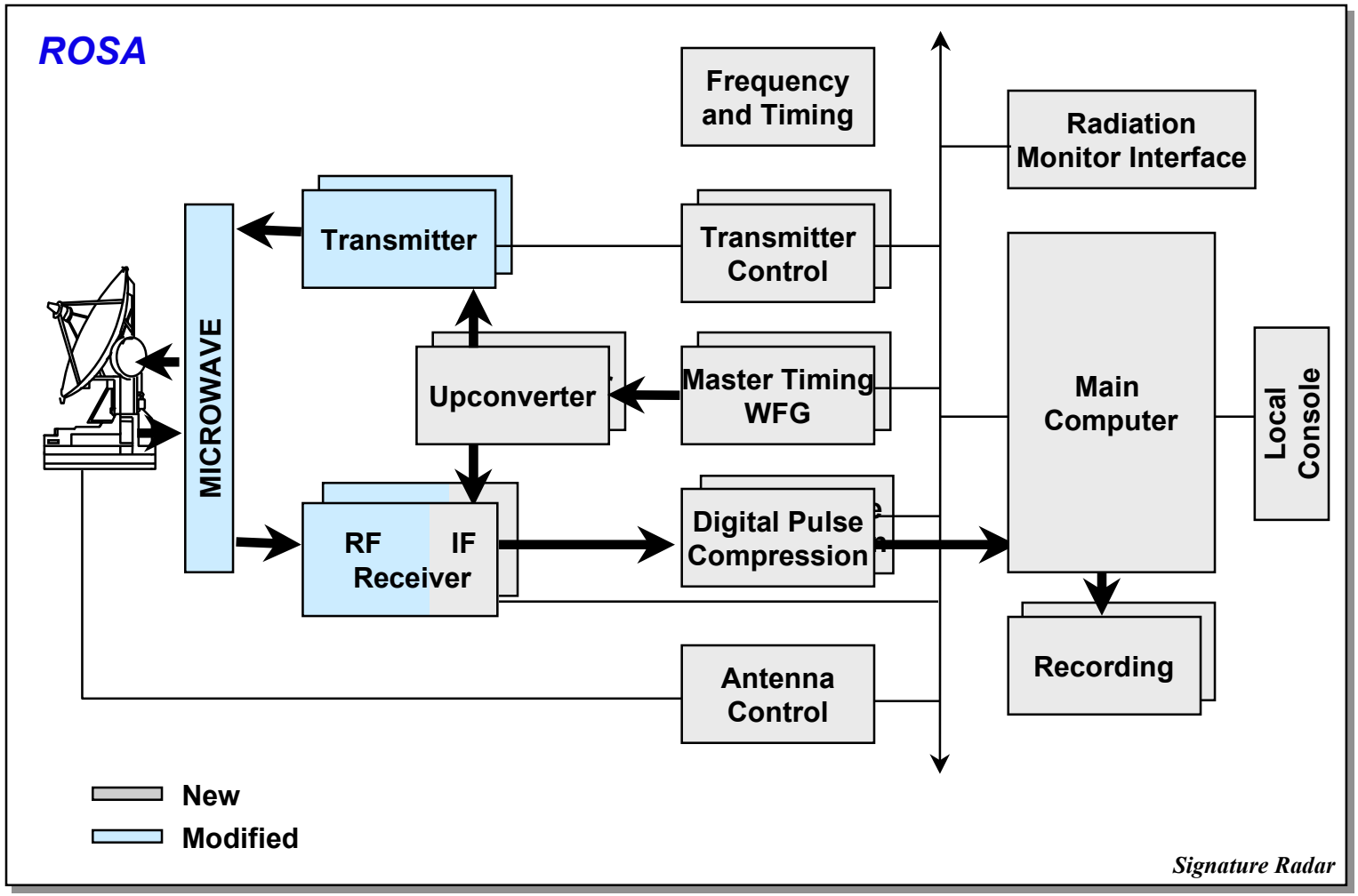
- **Traditional Radar Systems Model**
  - Master computer and centralized hardware
  - Custom development, proprietary HW & SW



- **Open Systems Architecture**
  - Radar functionally decomposed into building block components
  - Industry standard COTS hardware and interfaces
  - Components available for technology transfer

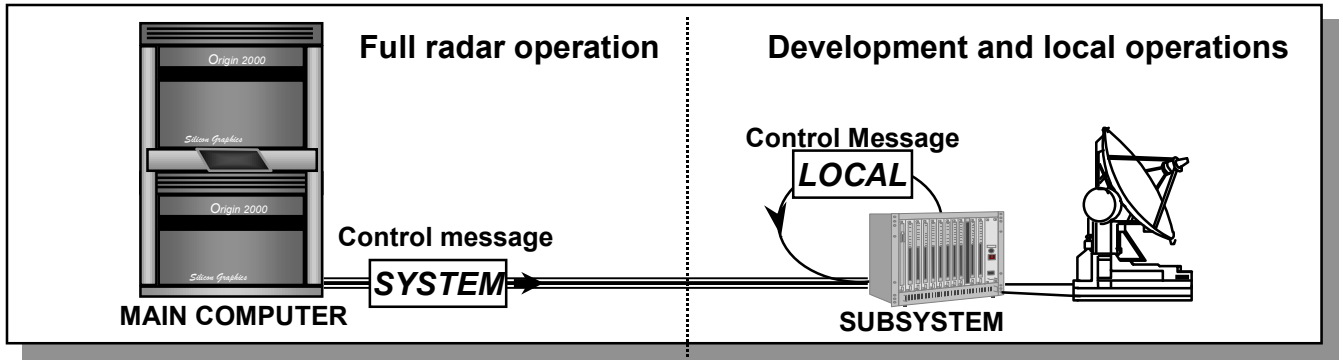


ROSA Block Diagram

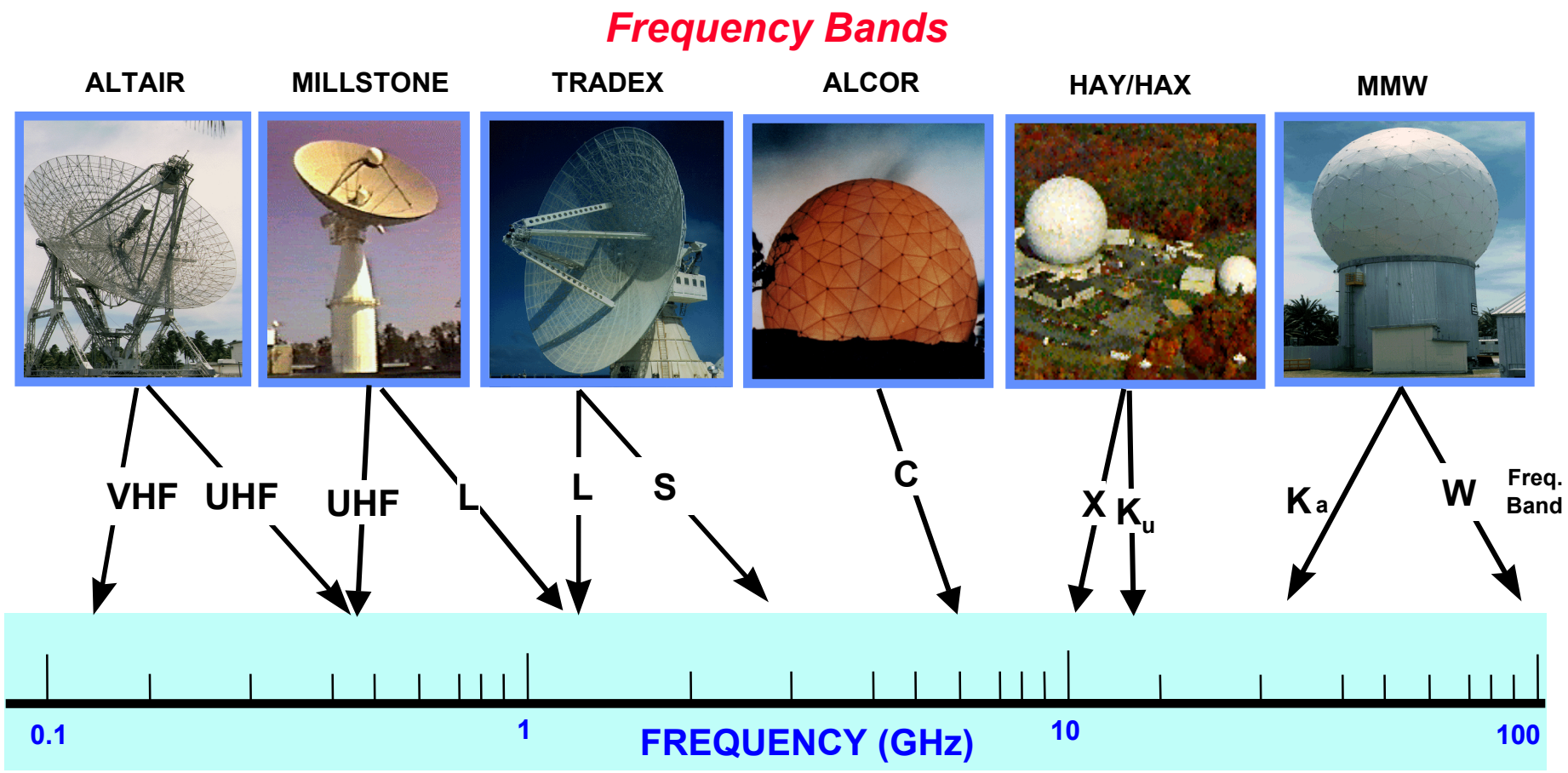


ROSA Benefits

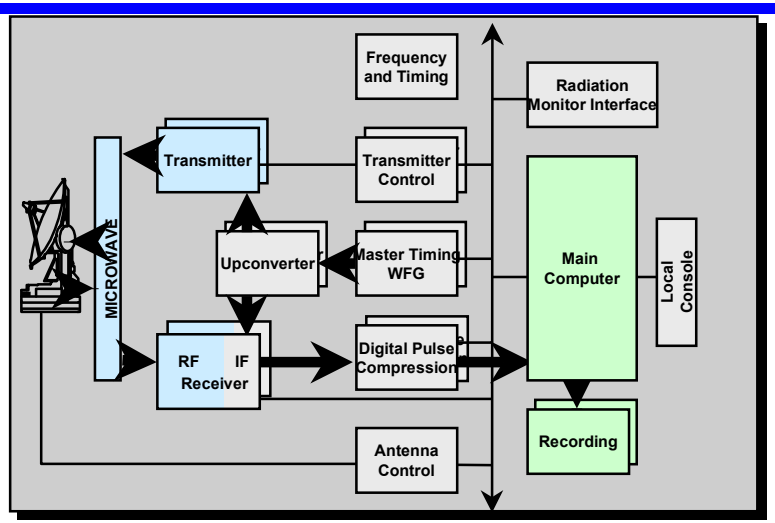
- Reduced development time and O&M cost
- Decomposition provides efficient use of engineering resources
  - Allows many small development teams (distributed locations)
  - Concurrent integration, test and evaluation
- Components easily added, shared and modified
  - Migration to new technology can be done at the unit level
- New developments can begin with working components
  - Better acquisition model, reduced NRE
- Subsystems encapsulate specific radar function
  - Underlying hardware and software is hidden
- Communication is key to architecture
  - Subsystem components completely define their functionality and interfaces to the outside world

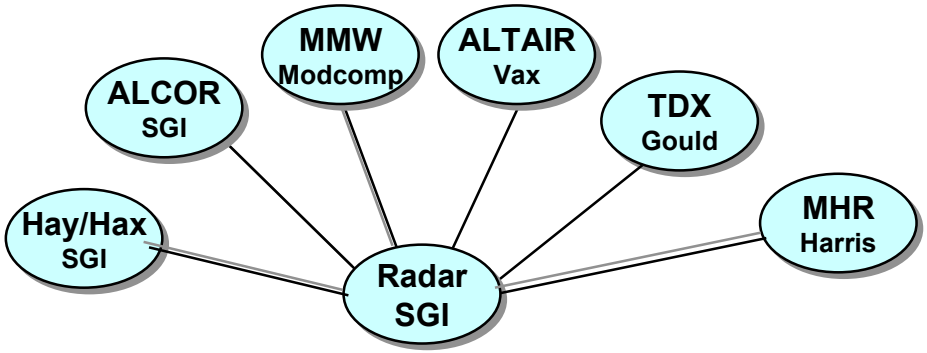


Lincoln Laboratory Modernization Radars with *ROSA*



Main Computer Real Time Program (RTP)





- Common radar software for all radars
  - 70% reduction in lines of code
  - 85% reduction in languages/OS/Platforms
- Enormous capability
  - >150 waveforms supported
  - 16 Channel coherent integration and detection
  - Multi-Target-Tracking (64 targets)
  - Bayesian Classifier (WB features)
  - Automated script-driven operations
  - Space surveillance functions
  - Common data recording format (> 80 Mbytes/sec)
  - Full PRI rate digital simulation
    - 64 targets and simulated targets over live data

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Kwajalein Radar Modernization

- 80% Reduction in custom hardware
  - > 85 % COTS
  - Seven custom boards for all Radars
  - 70% reduction in number of racks
- Automated and remote operations/diagnostics
- Dramatic improvement in flexibility

New common radar system

HAY/HAX Modernization

Disk Recording | Radar Computers | Digital Pulse Compression | Master Timing

HAY Transmitter Control System (TCS) | Master Timing System (MTS)

LSSC Software Development for Core RTP

- **Debris Mode**
  - **Stare at Fixed Azimuth and Elevations and detect and record Debris objects as they go through beam**
- **Trajectory Scans (α/β Scan) & (Progressive α/β Scan)**
  - **Scans along satellite trajectory in time and orthogonal by beam width**
- **Satellite Tracking Displays**
  - **Simplified Displays for Satellite Tracking**
- **Selective Radar Channel Recording**
  - **Ability to record selective Radar Channel data (PP; PP/OP or all four channels)**
- **Deep Space Tracking (MHR SATCIT)**
  - **Integrate SATCIT on MHR and then HAY and HAX radars**

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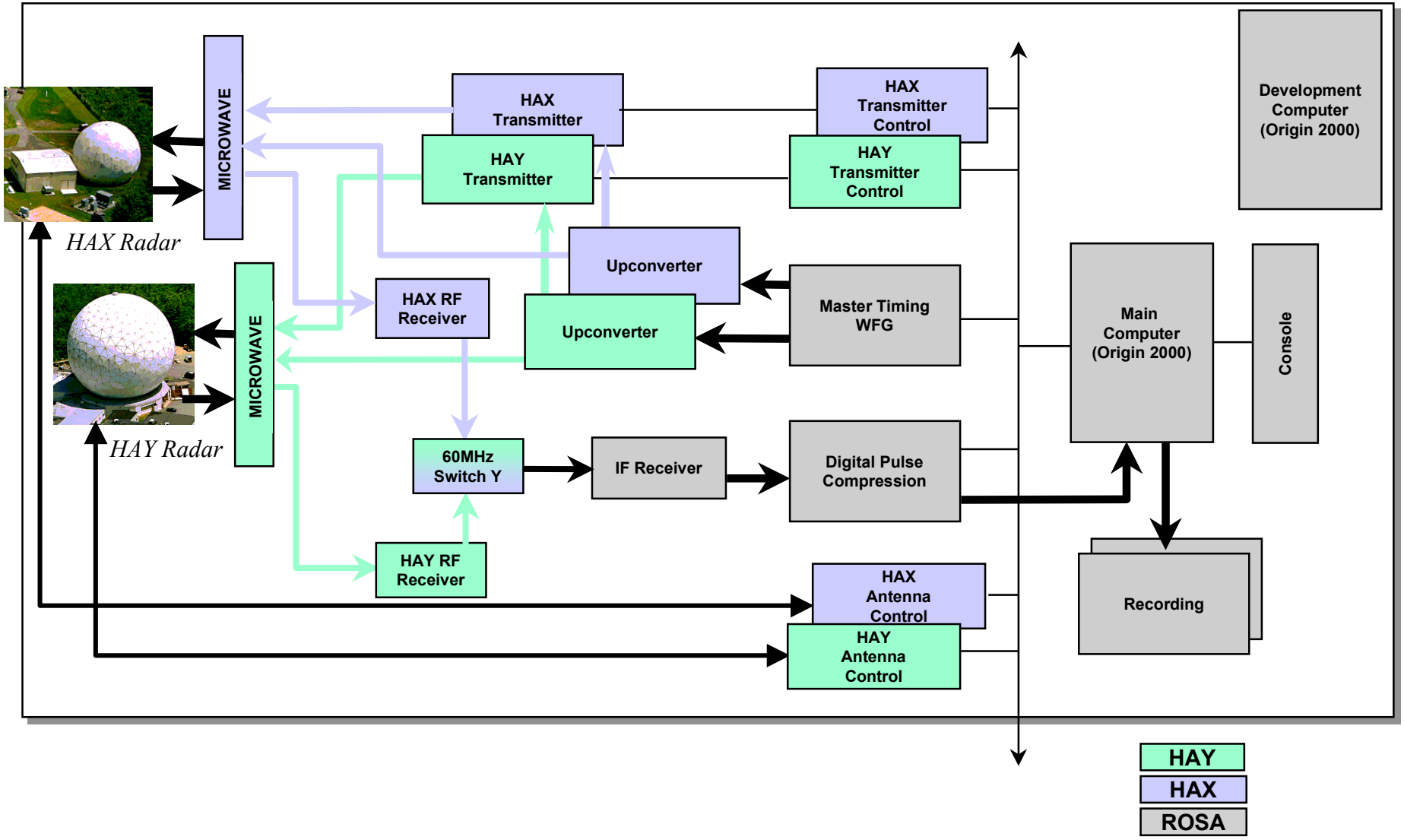
New LSSC Development Efforts

- **Wideband Network Sensors (WNS)**
  - **High speed network demonstration with Radar Data >1gbit/sec**
  - **Second Signal Processing System to allow dual HAX/HAY operation**
- **Wideband Waveform Generator Development**
  - **Initial development of Medium Bandwidth Waveform Generator (MBWFG) with 64MHz Bandwidth clocking at 320MHz**
  - **Future development of Wideband Waveform Generator (WBWFG) with 256MHz Bandwidth clocking at 1GHz**
- **Photonic ADC Technology (PACT) System**
  - **Multiple Phase Program with initial sampling of PP data only at 63.125 MS/s and future sampling to 505 MS/s**

HAX/HAY ROSA Modernized Block Diagram (Pre-WNS)



HAX/HAY ROSA WNS Block Diagram

MICROWAVE

Transmitter

Transmitter Control

Upconverter

Master Timing WFG

Receiver

Digital Pulse Compression

Antenna Control

Add on R12000 CPU board

Main Computer

Console

Recording

HAX Radar

Giga bit Ethernet

MICROWAVE

Transmitter

Transmitter Control

Upconverter

Master Timing WFG

Receiver

Digital Pulse Compression

Antenna Control

Add on R12000 CPU board

Main Computer

Console

Recording

HAY Radar

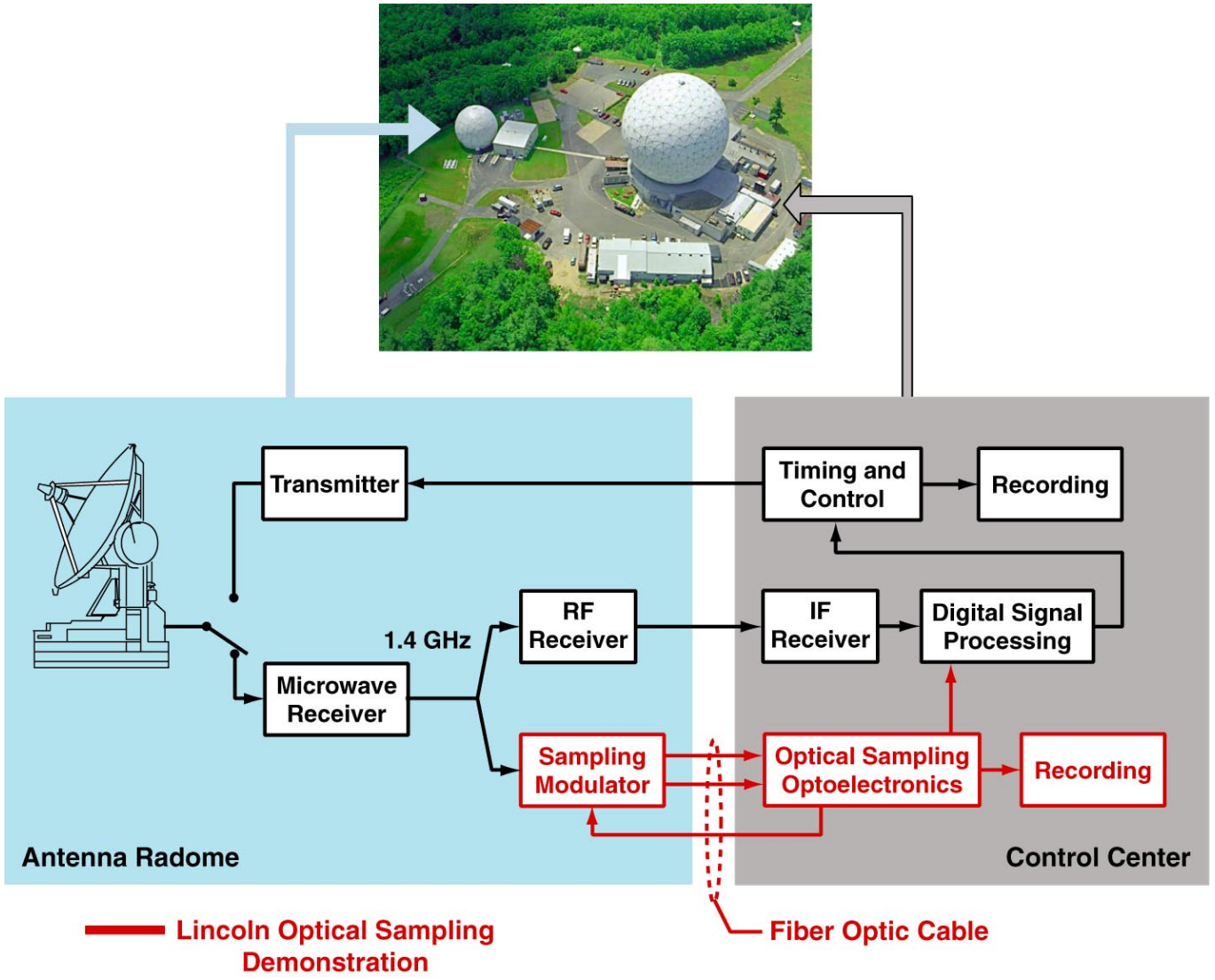
Giga bit Ethernet

High Speed Router

To Lincoln Lab

WNS Hardware

PACT Radar Demonstration



PACT Objectives at HAX

FY00/01 (Internally Funded) **Single receiver channel integration and test**

- Install fiber between control room and HAX antenna
- Fabricate new Correlation Receiver
- Fabricate 63 MS/s PACT system
- Integrate subsystems
- Record data for post-processing

F_s=63.125 MS/s
31.5 MHz BW @ 1.38 GHz
66 dB SNR 70 dB SFDR

FY01/02 (Not Funded) **Initial system demonstration**

- Single receiver channel wideband imaging
- Investigate real-time processing
- Investigate 4-channel implementation

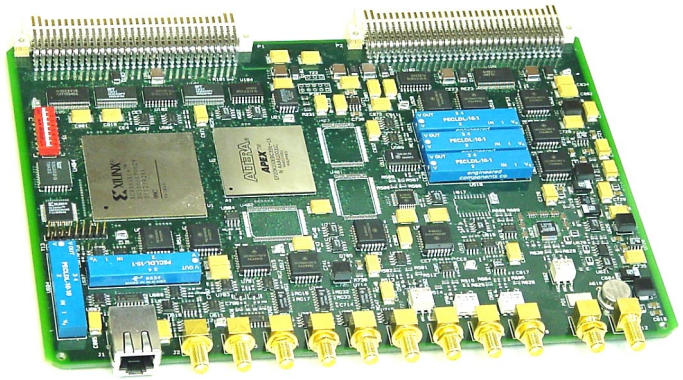
F_s=505 MS/s
8 x 63.125 MS/s, 1:8 optical
252.5 MHz BW @ 1.38 GHz
72 dB SNR 80 dB SFDR

FY02/03 (Not Funded) **Extended bandwidth demonstration**

- Single channel extended bandwidth imaging

Waveform Generators Development

- **Medium Bandwidth Generator**
  - **Simplified IRP Wide Bandwidth Generator**
  - **Single Slot VME 6u-160**
  - **Interfaces directly to Master Timing System Start Trigger**
  - **Arbitrary Waveform Capability**
  - **COTS Analog Devices DAC at 320MHz with 64MHz Bandwidth**
- **Wide Bandwidth Generator**
  - **Same as Medium Bandwidth Generator**
  - **Clock at 1000MHz with 256MHz Bandwidth**



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LSSC Modernization Status

- Haystack Auxiliary Radar (HAX)
  - Tracking & Imaging operational
  - Debris in data verification mode
- Haystack Radar (HAY)
  - All subsystems operational except Transmitter which is being integrated with ROSA
- Millstone Hill Radar (MHR)
  - All Modernization Hardware has been procured
  - Antenna Control System is being integrated with ROSA
  - Deep Space Tracking (SATCIT) software being rewritten in modules that can be incorporated into KMAR CORE RTP

Summary

- Radar Open Systems Architecture *(ROSA)* dramatically reduces the development time and cost of building radar sensors
  - Efficient use of engineering resources
  - Abstraction of hardware layer from software
  - Portable building block components
- Major use of *ROSA* in large radar development and modernization programs
  - Dual Band Radar - 2 year development of land-based radar
  - Kwajalein Missile Range - Common architecture for 4+ radars
  - LSSC - Common architecture for 3 radars & large cost saving
- Technology migration of *ROSA* components to industry
  - Technology transfer within the DOD is more efficient at the component level than the system level
  - Future radar development could start with existing plug and play components from the commercial marketplace